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may be the result of the increased permeability and oxidation. Perhaps the increased oxidation in fertilized eggs caused by alkaline NaCl is due to still further increase in permeability to OH-ions.

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WOODS HOLE, MASS.,  
August 11, 1911

#### THEORIES OF ELECTRICAL DISCHARGE

THE present attitude of the scientific mind on the one-fluid and the two-fluid theories is amusingly similar to the conditions in the early part of the last century concerning theories of light. The emission theory and the wave theory were both well known. Either could be held by any one who chose to do so. Either would serve as a means for explaining phenomena. The emission theory had the advantage. It had come down through generations from a revered source. There is such a thing as mental inertia. Fresnel and Young learned this. When they fully explained phenomena on the theory of transverse vibrations which could not be explained by the emission theory, it had little effect. They devised new experiments which could not be explained by Newton's theory. They explained the phenomena of Newton's rings on a rational basis. It all counted for nothing. Newton's followers might not be able to explain what it was that happened when light had a fit of easy transmission, or a fit of easy reflection. It was, however, evident that the fits were there, for Newton's rings gave evidence of it.

Every one will of course admit that the two-fluid theory has served a useful purpose. It has, however, also led us astray. It has led us to take a wrong view of phenomena.

When it is said, for example, that hot metals emit positive ions, the idea conveyed is very different from that which would be conveyed by the statement that hot metals take negative corpuscles from the gas molecules which surround them.

If one were to say that householders all over the country are emitting mail-carriers, the idea conveyed would be definite and very mis-

leading. As a matter of fact they are receiving their mail. The mail-carriers simply bridge the gap between the conduction channels along the railways, and the householder.

Of course it is perfectly evident that positive ions such as exist in discharge through gases can not circulate or flow through a copper wire. They simply vibrate to and fro between the terminals. The copper wire is itself a solid aggregation of positive ions. The negative corpuscles pass in rhythmical transfer from molecule to molecule within the wire. All of the phenomena of the vacuum tube and of discharge across air gaps are merely incidental to the condition that at that point the conductor is in gaseous form. The Faraday dark space is simply a region in which molecules, supercharged in the region of negative glow, are urged away from the negative terminal, without appreciable interchange or transfer of the negative corpuscles from molecule to molecule.

The positive or luminous column is a region in which this transfer is going on. These two regions may exist side by side. A small windmill made of non-conducting material is then driven in opposite directions in the dark and the luminous columns. The luminous columns are simply "canal rays." The carriers are returning after having delivered all of their supercharge and part of their normal charge.

These dark and luminous regions may, under proper conditions, exist as striations. They are then electrically produced sound waves.

The positive terminal of an influence machine is an exhaust terminal. Negative corpuscles from the surrounding air are drained into it. A disruptive discharge can be made to end in such a drained region, as "sheet lightning," before the positive terminal is reached.

Every lightning discharge which has its terminals in air must at its positive end be a region of "sheet lightning." It is probably often at higher altitudes than the rain-clouds. The negative end is usually within the clouds, and that end is "forked lightning."

Papers which contain photographic evidence that seems conclusive and which leads to the above conclusions have been recently published by the Academy of Science of St. Louis. They give a rational explanation of older phenomena which had not been explained on the two-fluid theory. For example, why are positive and negative Lichtenberg figures so different in form? How are we to explain the arc-like form of discharges, shorter than the critical spark length? What is the critical spark length? An additional suggestion may be made.

Assume two spheres of mass  $m$  and  $m'$ . They attract each other with a force  $Kmm'/r^2$ . Assume that the spheres are connected by means of a flexible conductor, and that negative corpuscles are pumped out of, or forced into the two masses. A condition will be found for which the attraction between these two masses will be a maximum. If the number of corpuscles in the masses be then either increased or diminished, the attraction will be less. With small masses we can easily reduce the attraction to zero, or make it negative.

Why should we continue to say that in one of these cases we are adding positive electricity to these spheres, when we are all fully convinced that we are not?

The attraction in dynes between these masses of radii  $R$  and  $R'$  cm., and distant from each other  $r$  cm., the matter composing them having a density  $\rho$  is

$$A = \frac{RR'}{r^2} \left( \frac{1}{9} \pi^2 \rho^2 KRR - V^2 \right).$$

This force will be zero when

$$V = \frac{4}{3} \pi \rho \sqrt{KRR'},$$

where  $V$  is potential in electrostatic units. This last condition does not depend upon the distance of these bodies from each other (neglecting mutual induction), but upon the magnitude of the bodies.

For two bodies having the size of the moon and earth, assuming that they have a density  $\rho = 5.5$ , the potential must be raised to  $1.96 \times 10^{17}$  volts, in order that they shall cease to attract each other.

The last equation may also be written

$$K\rho^2RR' = 9\sigma\sigma',$$

where  $\sigma$  and  $\sigma'$  are surface densities on the two bodies.

The interesting suggestions of Arrhenius in regard to the invasion of our atmosphere by corpuscular radiation, suggest that the actual potential of earth and moon are not widely different. While these considerations are perhaps of no astronomical significance, they nevertheless lead us towards a general conclusion which seems to have some interest.

May we not conclude that Newton's equation for gravitational attraction represents a special case, in which all of the molecules in both masses possess what might be called the normal number of corpuscles?

If one mass is in normal condition and the other is "charged" as above, Newton's equation also represents a special case, the discussion for which is apparent.

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